DOCUMENT RESUME

ED 267 758 IR 012 126

AUTHOR Canelos, James; And Others
TITLE External Pacing as an Instructional Strategy for the Design of Micro-Computer Based Instructional Programs to Improve Performance on Higher Level Instructional Objectives.
PUB DATE 10 Dec 85
NOTE 20p.; Paper presented at the Annual Convention of the Association for Educational Communications and Technology (Las Vegas, NV, January 16-21, 1986). For entire proceedings, see IR 012 121; for a related paper, see ED 256 310.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Analysis of Variance; Cognitive Processes; Cognitive Style; *Computer Assisted Instruction; *Conceptual Tempo; Hypothesis Testing; Individual Differences; *Instructional Design; *Intermode Differences; *Microcomputers; *Pacing; Research Methodology; Tables (Data); Time Factors (Learning); Visual Learning
IDENTIFIERS AECT Research and Theory Division Meeting; *External Pacing; Instructional Effectiveness

ABSTRACT

Research was conducted to further investigate the results of an earlier 1985 study (Dwyer, et al.) which found that a moderately externally-paced microcomputer-based instructional program was more effective than either a self-paced or a more aggressive externally-paced condition. Instructional programs (heart parts and verbal labels) were identical to the earlier study; the only overall change was the addition of a 5-second delay after presentation of a visual in which no verbal instructions were presented. Two of the instructional conditions provided an imaging cue which occurred with every five to seven instructional displays in the sequence of 57 displays. Two hundred subjects (freshmen from Ohio State University) were randomly assigned to four instructional conditions, and then randomly assigned to the imagery training and no training groups within their instructional condition. Analysis of variance was conducted on data collected from 168 subjects. Results indicate the visual delay forced the subject to concentrate on the visual display of the heart and labels, thus improving overall information processing. This information supports the hypothesis that putting the learner in complete control of instruction may not be the best teaching method for computer-based instruction. Additionally, the existence of an external control, i.e., a cue to form images, may provide students with needed support. Seven data tables, two figures, and a list of references are provided. (JB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
OERI
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
X This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official position or policy.

ED267758

EXTERNAL PACING AS AN INSTRUCTIONAL STRATEGY FOR THE DESIGN OF MICRO-COMPUTER BASED INSTRUCTIONAL PROGRAMS TO IMPROVE PERFORMANCE ON HIGHER LEVEL INSTRUCTIONAL OBJECTIVES

James Canelos, Ph.D.
Research Associate in Instruction
The Pennsylvania State University

Patti Baker
Doctoral Candidate, Education
The Ohio State University

William Taylor, Ph.D.
Associate Professor of Education
The Ohio State University

John Belland, Ph.D.
Associate Professor of Education
The Ohio State University

Francis Dwyer, Ed.D.
Professor of Education
The Pennsylvania State University

December 10, 1985

IR013136

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Michael Simonson
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Rationale

At the 1985 AECT Convention in Anaheim, CA, the authors presented a research study titled, "Varied Self-Paced Micro-Computer Based Instructional Programs for Addressing Individual Differences When Acquiring Different Levels of Instructional Objectives". A refined version of this study was later accepted for publication in a special issue of ECTJ dealing with micro-computer based instruction and individual learning differences. The *1985 AECT RTD paper presented some unique results regarding the design of micro-computer instructional programs. These results tend to be in opposition to past instructional systems designed to address the problem of individual learning differences by the use of a self-paced instructional method. However, the 1985 AECT RTD paper results were consistent with current cognitive psychology principles, indicating that attending and motivation are strong predictors of successful learning when dealing with improving information processing. In other words, what Wittrock (1978) and others (Yerkes-Dodson Law in Travers, 1972; Zeigarnick Effect and Ovsiankina Effect in DeCecco, 1963) have indicated is that by increasing motivation and attention, learning or information processing may also be increased. On the other hand, what self-paced instructional systems (i.e., Skinner's programmed learning; Glaser's IPI-system; and Postlethwait's Audio-Tutorial System; in Cross 1976) tend to do is put the locus of control for pacing in the learner's hands. This would tend to decrease external control, not only for pacing, but also decrease control over the manipulation of the student's attending behavior and motivating the student. A similar position has been expressed by Carrier (1984) and Reiser (1984), both noting that learner's may not be the best judges of what instruction they need, how much instruction, when to seek instruction, and what to attend to in an instructional segment.

The results of the 1985 AECT RTD paper clearly indicated that a micro-computer based instructional program, that is moderately externally paced, allowed for more information to be acquired, and for better performance on higher level objectives, than both self-paced and a more aggressive externally-paced condition. Our results fit the cognitive psychology literature quite well, but were in opposition to the research on self-paced instruction. However, little

---

*pp. 146-163 of the 1985 AECT RTD Proceedings, Authors Dwyer, F., Taylor, W., Canelos, J., Belland, J., Baker, P.

research has been done to date on the issue of self-paced instruction and micro-computers, probably because of the widely held erroneous assumption that self pacing is the best way to design micro-computer based instructional programs.

As can be seen in the results of our 1985 AECT RTD paper, summarized in the table of means, Table 6, the external paced plus cognitive processing time condition was superior to both the self-paced and the external-paced, no cognitive processing time conditions. These results are particularly significant when considering that the subject's performance in the external paced plus cognitive processing time condition held constant, even though intellectual task difficulty increased significantly going down the table. Table 7 provides a summary of the analysis of variance results of the 1985 AECT RTD study.

Given the unique results of the 1985 AECT RTD study, and their significance in predicting how to design micro-computer based instruction, the authors have decided to conduct a series of studies to further investigate these results. Since the external control of pacing had such a significant effect on learning, by manipulating attention and motivation, it is likely that further external controls can have an effect upon learning or information processing. These external controls should be designed to control attending behavior and motivation when interacting with visual and verbal information from the micro-computer based instructional program. Looking at the table of means in Table 6 indicates two distinct effects occurring. First the spatial problem free-recall scores are quite low when compared to the other test scores. This even occurred in the Externally Paced plus Cognitive Processing Time Condition. This low score probably occurred because subjects were attending to mostly verbal information and not the spatial or visual information required to solve the spatial free recall problem. As indicated in the 1985 AECT RTD paper, the instructional sequence presented the subject with a visual and a set of verbal information. Each instructional question then required the subject to respond with verbal information. However, visual/spatial information was a part of this to-be-acquired information, but the learner was not directly forced to attend to this information. To externally control this attending to visual information, the instructional program was changed to include a 5 second time delay after the visual was presented, but prior to any verbal information being presented. The presence of visual/spatial information, and the absence of verbal information should presumably direct the learner's attention to the visual information. To further control

the learning of spatial information, every 5 to 7 instructional displays the learner was given a cue to try to form a mental image of the visual/spatial information seen so far. This was done by including a special instructional display that formed an outline of the heart, with verbal directions that asked the learner to try to fill in the parts he or she had already seen by forming a mental image. The second effect noted in Table 6 is the wide range of scores across the test types in the Self-Paced and External Paced No Cognitive Processing Condition. It was felt that the 5 second visual delay variable would tend to level off these scores by forcing subjects to more carefully attend to information presented. While these external manipulations of a 5 second visual delay and a cue to image, seem like a small amount of external control, recall that a 7 second delay caused the differences in scores between the Ep + Cp, Sp and Ep - Cp conditions the 1985 study. As indicated in the 1985 AECT RTD paper, cognitive style variables should be examined in terms of effects upon learning when different micro-computer based instructional conditions are used. The cognitive style variable examined in this study was reflectivity and impulsivity. A final variable examined was the effect upon learning of a simple imagery strategy to further control information processing. The four theoretical hypothesis examined in this study were:

1) The external control of a 5 second visual delay will improve overall learning from the instructional programs and particularly the processing of visual and spatial information, for use on spatial learning tasks.

2) A cue to form an image will improve learning on spatial tasks when compared to those subjects without imaging cues.

3) Reflectives will tend to respond more favorably to micro-computer instructional programs than impulsive cognitive styles who probably require more external control than CAI can afford.

4) Imaging training will improve visual learning overall if given prior to working with CAI.

Experimental Design

The present study is a research in progress and was completed on November 8 and 9, 1985, at Ohio State University. The data analysis completed to date appears in Tables 1 thru 5, and Figure 1. This analysis can be compared to the results of the 1985 AECT RTD study found in Tables 6 and 7. Further analysis will be done with

the resulting data, and the reflectivity-impulsivity data will be added to this further analysis in addition to a more comprehensive literature review on this cognitive variable. Further, a complete description of the instructional programs and test types/intellectual tasks will be not included in this review but can be found in the 1985 AECT RTD paper, pp. 146-163. However, modifications in those micro-computer based instructional programs will be considered.

The experimental design appears in Figure 2, and is a (4 x 5 x 2 x 2) design. There are 4 basic instructional conditions, as indicated earlier, a 5 second visual delay was added to each instructional condition to improve attending to visual information. The instructional programs are the same used in the 1985 AECT RTD study. However, the external paced no cognitive processing time condition is not used in this study. The programs are micro-computer instructional programs designed to teach the names of the parts of the heart, the heart phases and operations. There are 57 instructional frames in each instructional program, and these are identical to the 1985 AECT RTD study programs. The only overall change in each instructional condition was the addition of the 5 second visual delay, this delay occurs in the following manner. Each instructional display consists of a visual of the heart and relevant heart parts and verbal labels, then under the visual a segment of verbal information appears describing the visual and verbal labels. This information is then removed from the CRT screen, a study question appears, and the learner types in the appropriate answer. To force the learner to attend more carefully to the visual information, a 5 second visual delay occurs after the heart visual and part labels appear on the screen, prior to any verbal instruction appearing under the visual. At this point, the learner is forced to attend to the visual information. After several frames the learner seems to realize that this visual information must be important. Two of the instructional conditions provided an imaging cue, that helped the learner recall prior visual information during the instructional sequence. This imaging cue occurred every 5 to 7 instructional displays in the sequence of 57 displays. The image cues consisted of an outline visual of the heart appearing on the screen, then a verbal segment told the learner to try to fill in the outline drawing with heart parts he or she had already seen by forming an image in the mind. The learner had as much time as needed to think about this image. The 4 basic instructional programs were the:

(1) Self-Paced Instruction - 5 sec. delay - no imaging cue

(2) Self-Paced Instruction - 5 sec. delay - imaging cue
(3) External-Paced Instruction - 5 sec. delay - no imaging cue
(4) External-Paced Instruction - 5 sec. delay - imaging cue

There were 5 types of tests or intellectual tasks. These tests were identical to those given in the 1985 AECT RTD study and are described in detail in that study. The tests represent specific intellectual tasks, and were designed to range in difficulty from a simple task to a difficult task and were called:

(1)	List learning test	Less Difficult
(2)	Spatial learning test, cued recall	
(3)	Simple concept learning test	
(4)	Complex concept learning test	
(5)	Spatial problem test, free recall	More Difficult

The cognitive variable was the reflectivity versus impulsivity variable. As the name implies, the reflective cognitive style tends to take more time with information based decisions, while the impulsive cognitive style tends to have as the main goal; "getting things done quickly." reflectivity-impulsivity was determined using Barratt's test, (Barratt and Patton, 1983). The test was given on-line to subjects prior to beginning the instructional programs, and scores were recorded for each subject. While the reflectivity-impulsivity variable data has been collected, the data has not yet been added to the currently analyzed data. It was assumed that reflectives may be more adept at using micro-computer based instruction than impulsives, indicating that the impulsive cognitive style may need more external control in the learning environment than typical methods of CAI can provide.

The last variable examined was the imagery training variable. It is likely that training subjects to form images would help them acquire visual information better, than no such prior training. The image training group had a brief workshop on how to form mental images by hearing an explanation of the value of imagery in learning, and practicing forming images of objects. The workshop consisted of a video-taped demonstration and explanation of an imagery strategy.

Subjects participating in the study were 200 freshmen from Ohio State University. Subjects received points toward their final grade in freshmen psychology for participation. Subjects were randomly assigned to the 4 instructional conditions, and from there randomly

assigned to the imagery training and no training groups. Subjects were run through the study conditions over a period of two days. Data was calculated on 168 subjects who completed the study, yielding an equal 42 subjects in each of the 4 instructional conditions.

Preliminary Analysis and Results

The analysis was conducted using a 4 x 5 x 2 analysis of variance with repeated measures. A complete analysis using the reflectivity-impulsivity variable will be conducted at a later time, and this will yield the complete 4 x 5 x 2 x 2 experimental design found in Figure 2. A table of means for the overall experimental design can be found in Table 1.

The analysis of variance is summerized in Table 4. Table 4 indicates that the significant differences found last year (see Table 7) on the instructional type condition have been eliminated. Looking at the pattern of means found in Table 2 indicates that the differences across test conditions have been leveled off to enough of an extent to eliminate a significant difference on the instructional conditions. In other words, in a general sense, the Self-Paced and External-Paced instructional conditions provided for similar test performance. It should be noted that the External-Paced condition in the present study is the External-Paced plus Cognitive Processing Condition from the 1985 study, the External Paced No Cognitive Processing condition was not used. It is likely that this overall improvement in test performance over last years study was a result of adding the 5 second visual delay to each of the instructional conditions. This visual delay forced the subject to concentrate on the visual display of the heart and labels, thus improving overall information processing. Comparing Table 6 and Table 2, emphasizes this overall performance difference between the 1985 AECT RTD study and the present study. Looking at Table 6 and Table 2 also reveals the significant increase in scores on the Spatial Learning Problem test in the present study. Note that the average score on this test in the present study was 9.71 points, compared to 6.55 points in the 1985 AECT RTD study. It is likely that the 5 second visual delay caused the learner to attend more carefully to visual/spatial information, thus improving scores on the Spatial Learning Problem Test.

Significant differences are found between test types, or intellectual tasks (Table 4). These differences are further analyzed in Table 5, and the results indicate that the tests do range in difficulty, making the spatial learning problem free recall, the most difficult task.

Of particular interest is the interaction found in Table 4 between test type and instructional condition. This interaction is displayed in Figure 1, and the means involved in this interaction are presented in Table 2. A Tukey method has been conducted on the means involved in this significant interaction. The complete analysis of these means will not be presented here, however, the source of the interaction was the different pattern of means occurring in the External-Paced Image Cue condition. The scores in this condition tended to be higher than the other three conditions, particularly the score on the Spatial Problem Free Recall (see Figure 1). Similarly, the Self-Paced Image Cue condition yielded a higher score on the Spatial Problem Free Recall Test, contributing to this interaction. Further analysis of this interaction is planned in a future presentation of the results of this study.

Conclusions

The preliminary results of this study indicate that external control of instructional conditions, in micro-computer based instruction, can improve information processing. These results further support the notion that putting the learner in complete control of instruction, via a self-paced condition, may not be the best teaching method for CAI. Specifically, these preliminary results supported our first hypothesis, indicating that a 5 second delay after visual information is presented on the CRT can improve learning of visual and spatial information. This 5 second delay probably caused the learner to attend more carefully to visual information and therefore process more visual information. While a 5 second delay seems slight, it did improve scores on the Spatial Problem free recall test over the 1985 AECT RTD study, and tended to improve test scores in general. Additionally, support was found for the second hypothesis, indicating that a cue to form images, as a form of external control, improved performance on the Spatial Learning Problem. Students may need this type of cueing to help them process information and tell them what is important and needs to be acquired in the instructional sequence. The imagery training probably did not have a noticeable effect because of the beneficial effects of the 5 second delay and image cueing.

Overall, the External-Paced condition plus cognitive processing time (from the 1985 AECT RTD study) with an imaging cue, was the better of the three

micro-computer based instructional conditions. Further analysis is planned by adding the reflectivity-impulsivity variable, and further analysis of the instruction by test interaction will be carried out in a future study presenting this data.

	Self-Paced 5 sec Delay (No Image Cue)		Self-Paced 5 sec. Delay (Image Cue)		External-Paced 5 sec. Delay (No Image Cue)		External-Paced 5 sec. Delay (Image Cue)		$\bar{X}$ 1-5
	Image Trained	Not Trained	Image Trained	Not Trained	Image Trained	Not Trained	Image Trained	Not Trained	
List Learning Test	11.81	10.67	13.10	14.48	11.86	13.67	15.0	12.86	12.93
Spatial Learning Test	13.38	12.86	12.10	14.48	12.71	14.67	14.14	14.33	13.69
Simple Concept	11.91	11.81	11.29	12.33	11.52	12.86	11.67	13.33	12.09
Complex Concept Test	11.91	11.14	10.86	11.67	11.86	11.91	11.76	12.48	11.70
Spatial Problem Free Recall	9.19	8.10	10.29	10.52	9.43	9.67	10.71	9.76	9.71
$\bar{X}$...IT/NIT	11.64	10.91	11.70	12.70	11.48	12.55	12.66	12.55	
$\bar{X}$...SP/EP	11.28		12.20		12.01		12.61		
	Image Training $\bar{X}$.... = 11.87				No Image Training X... = 12.18				

Table 1: Overall Table of Means

Instruction Condition / Learning Task	Self-Paced No-Image Cue	Self-Paced Image Cue	External-Paced No-Image Cue	External-Paced Image Cue
1) List Learn	11.24	13.79	12.76	13.93
2) Spatial Cued	13.12	13.71	13.69	14.24
3) Simple Concept	11.86	11.81	12.19	12.50
4) Complex Concept	11.52	11.26	11.88	12.11
5) Spatial Free	8.64	10.41	9.55	10.24

Table 2: Instructional Condition X Test-Learning Task Interaction Means

	Image Training	No Image Training
List Learn	12.94	12.91
Spatial Cued	13.30	14.08
Simple Concept	11.60	12.58
Complex Concept	11.60	11.80
Spatial Free	9.91	9.51

Table 3: Learning Task X Image Type "Almost Interaction" Means

Source (BG)	Mean Sq.	Df	F-Ratio	Probability
Instruction Type (A)	64.814	3	1.092	.35
Image Type (B)	20.430	1	0.344	.56
(A) x (B)	40.321	3	0.679	.57
Error	59.372	160	---	---
(WG)				
Test Type (C)	380.909	4	63.258	.0001
(A) x (C)	11.503	12	1.910	.03
(B) x (C)	13.683	4	2.272	.06
(A) x (B) x (C)	7.417	12	1.232	.26
Error	6.022	640	---	---

Table 4: Analysis of Variance Results;
2 x 4 x 5 Design

(1) List Learning Test 12.93	12.93 - 13.69 = .76
	12.93 - 12.09 = .84
(2) Spatial Learning Cued Test 13.69	12.93 - 11.07 = 1.86
(3) Simple Concept Learning Test 12.09	12.93 - 9.71 = 3.22*
	13.69 - 12.09 = 1.6
(4) Comples Concept Learning Test 11.07	13.69 - 11.07 = 2.62*
	13.69 - 9.71 = 3.98*
(5) Spatial Learning Problem Test 9.71	12.09 - 11.07 = 1.02
	12.09 - 9.71 = 2.38*
	11.07 - 9.71 = 1.36
	(*Significant at .05 alpha)

Table 5: Mean Differences, Test Type or Learning Task, Using T-Method

	Self-Paced	External Pace, Norm Reading Speed + Cp	External Pace No Cp	Control	WG, X... Control In :
List Learning	12.36	12.48	11.84	1.92	9.65
Spatial Learning Cued	12.32	13.60	10.64	5.68	10.56
Simple Concept Test	11.00	12.80	8.88	7.12	9.95
Complex Concept Test	10.40	13.64	9.48	6.56	10.02
Spatial Problem Free-Recall	6.76	8.60	4.28	.88	5.13
BG, X...	10.67	12.22	9.02	4.43	
Avg. Time Overall	50.36 min.	44.64 min.	45.04 min.	n/a	

Table 6: Resulting Test Means and Overall Time for Each Instructional Program, 1985 AECT - RTD Study

Source	Mean Sq.	Df	f-ratio	Probability
BETWEEN GROUPS				
Instruction/ Pacing (A)	1404.359	3	45.875	.001
Error	30.613	96	---	
WITHIN GROUPS				
Learning Task, Test (B)	493.917	4	99.785	.001
(A) x (B)	51.901	12	10.485	.001
Error	4.949	384	---	

Table 7: Resulting Lindquist I, 4 x 5
Analysis of Variance Data, 1985 AECT - RTD Study

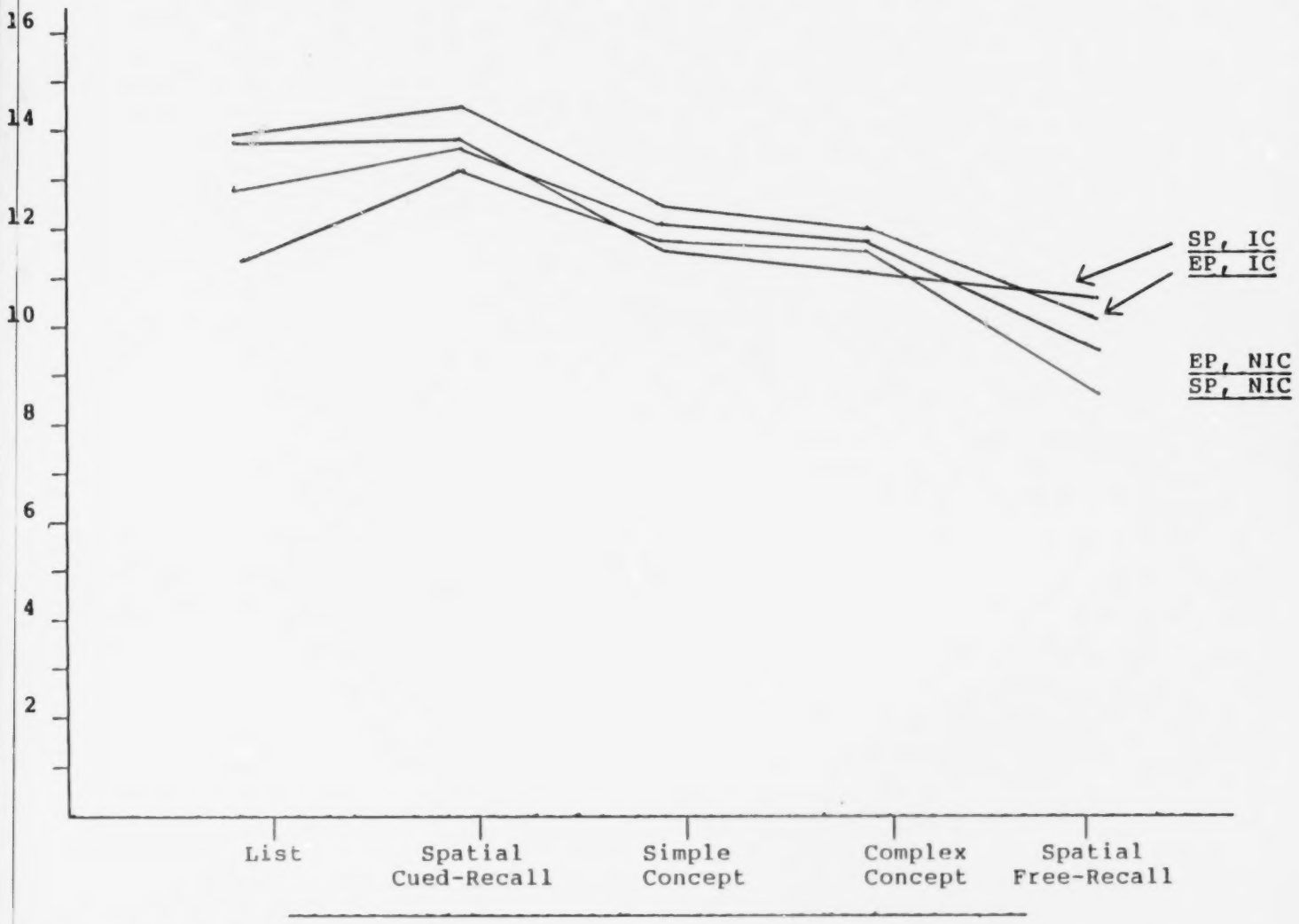

Figure 1: Graphic of Interaction; Instructional Condition x Test Type

SP, IC = Self-Paced, Image Cue
SP, NIC = Self-Paced, No Image Cue
EP, IC = External-Paced, Image Cue
EP, NIC = External-Paced, No Image Cue

	Self-Paced Instruction 5 sec. Delay No Image Cue		Self-Paced Instruction 5 sec. Delay Image Cue		External-Paced Instruction 5 sec. Delay No Image Cue		External-Paced Instruction 5 sec. Delay Image Cue	
	Image Trained	Not Trained	Image Trained	Not Trained	Image Trained	Not Trained	Image Trained	Not Trained
List Learning Test	Ref*	R	R	R	R	R	R	R
	Imp*	I	I	I	I	I	I	I
Spatial Learning Test								
Simple Concept Test								
Complex Concept Test								
Spatial Problem Free Recall								

*Cognitive Variable - Reflectivity vs. Impulsivity not yet analyzed for this write-up

Figure 2: Complete Experimental Design; 2 x 2 x 4 x 5 Analysis of Variance

References

Barratt, S. E. and Patton, J. H. (1983) Impulsivity: Cognitive, Behavioral, and Psychophysiological Correlates, (in) Biological Basis of Sensation Seeking, Impulsivity, and Anxiety, Hillside, N.J.: Lawrence Erlbaum.

Carrier, C. (1984) Do Learners make good choices? Instructional Innovator, 29 (2), 15-17.

Cross, P. K. (1976) Accent on Learning, San Francisco, CA: Jossey-Bass.

DeCecco, J. P. (1963) Human Learning in the School, New York: Holt, Rinehart, Winston.

Reiser, R. A. (1984) Reducing Student Procrastination in a Personalized System of Instruction Course, Educational Communications Technology Journal, 32, 41-49.

Travers, R. M. W. (1972) Essentials of Learning, New York: MacMillan Co.

Wittrock, M. C. (1978) The Cognitive Movement in Instruction, Educational Researcher, 8, 5-11.